

as the impossibility of selecting a representative diagram of the mean work of the steam that should be sufficiently accurate for showing the mean power developed in the cylinders during the whole of the test, rendered it hopeless to estimate the effect which the jackets had upon the state of the steam in the cylinders." The comparisons were on this account only available with tests made when the jackets were not at work. The following were the final conclusions arrived at:—For the same consumption of water and fuel per hour, the work done by the compound engine is greater than that done by the ordinary engine; for the same boiler-pressure and the same speed, the increase of work done by the compound engine compared with ordinary engines diminishes in proportion as the total consumption of fuel and water increases.

Mr. Sandiford's experiments were made on two locomotives which had been sent into the shops for heavy repairs, both of them requiring new cylinders. One was arranged with two high- and two low-pressure cylinders, and the other with one high- and one low-pressure cylinder. The compounding of both locomotives was attended with economy in consumption of fuel, and they were decidedly more powerful than the original engines had been, whilst from the drivers' point of view they were not more complicated.

The views held by the members taking part in the discussion agreed generally with those of the authors of the papers as regards the benefits both of jacketing and of compounding locomotives.

After the close of the discussion, the members visited various works in and around London, amongst those most favoured being the Royal Mint, Lambeth Pottery, the Royal Small-Arms Factory (Enfield), the Royal Arsenal (Woolwich), Beckton Gas-Works, the Royal Victoria and Albert Docks, Tilbury Docks, and the Crossness Swage-Works of the Metropolitan Board of Works.

#### PROGRESS OF CHEMISTRY AND MINERALOGY

M. FRIEDEL, President of the French Association which met recently at Nancy, gave an address on the progress of chemistry and mineralogy. After briefly referring to the ravages made by death amongst the founders of the Society, and to the prospect of its amalgamation with the Scientific Association of France, M. Friedel proceeded to remark that the progress of chemistry during a period of thirty years had been set forth with masterly clearness and attractive eloquence by the late M. Wurtz at the gathering held at Lille in 1874, and two years later at the Clermont Conference. The theoretical conquests resulting in the discovery of the brilliant coal-tar dyes, the reproduction of alizarin and the other colouring substances of madder, of vanilline (the odoriferous principle of vanilla), of indigo, of the tartaric and citric acids, &c., continue their progressive and pacific career.

The study of countless artificial compounds brings us daily nearer to the natural compounds that have not yet been reproduced, and the most important alkaloids, such as quinine and morphine, seem already almost within the scope of synthetical chemistry. The work that has been undertaken in their regard resembles that of architects engaged in raising stone by stone the plan of some edifice at once of intricate design and difficult access.

This plan once securely established, the reconstruction of the building itself will no longer lie beyond the power of those regular synthetic methods which are daily acquiring greater expansion. It will soon be a mere question of patience and intelligent work, and the time is approaching when quinine and morphine will be produced as readily as alizarin now is. Nay more, there is reason to hope that besides the natural alkaloids others will be obtained endowed with valuable therapeutic properties. While endeavouring to reproduce atropine, whose synthesis he afterwards succeeded in making, M. Ladenburg has obtained homatropine, which produces physiological effects sufficiently distinct to claim, side by side with its homologue, a place amongst the agents employed by oculists. Other less successful essays have also shown in the derivatives of quinoline that patients have perhaps been somewhat prematurely treated with agencies producing a vigorous and very special action on the organism.

If synthetic chemistry has a bright future, we shall also doubtless see the development of another branch of chemistry which has

hitherto been comparatively neglected, after having been held in honour at the beginning of the century, and found in Braconnot, of Nancy, an able and devoted cultivator. M. Friedel referred to the research of direct principles, that is to say, of the chemical compounds which exist in animals and plants, and which may be extracted from them. Similar alternatives are often presented in the history of science, which proceeds with irregular leaps, as results from the very nature of things.

The separation of the direct or immediate principles had first to place at the disposal of chemists abundant materials of varied composition, in order to fix their attention on the complexity of organic substances. Then came the time to seek the laws determining their constitution, and now that these laws are sufficiently understood to establish the structure and functions of many of them, the more complete study of their transformations, the more accurate definition of some already determined, the certain discovery of many others still unknown, must attract further attention to the work of those who, like Braconnot, have made a special study of the natural products.

Mineral chemistry has at last succeeded, in the hands of a young and skilful naturalist, in obtaining the isolation of fluorine, which had been in vain attempted by so many other students.

This important result is again due to the process used by Davy for isolating potassium—the decomposing action of the pile. The essay had already been made, but under conditions in which this exceptionally active element reacted on the electrodes or on the vessels. M. Moissan's merit consisted in perceiving that the decomposition should be made at a low temperature, and in the happy choice of the substance to be subjected to the process of electrolysis—hydrofluoric acid made conductive by the addition of fluoride of potassium. In the gaseous current disengaged at the positive pole, crystallised silicium and boron burn at the ordinary temperature, iodide and chloride of potassium are decomposed, mercury and other metals transformed to fluorides, organic compounds carbonised or inflamed, while water absorbs the gas, yielding in its place ozonised oxygen. Thus is produced a large number of reactions, whose study promises a most interesting sequel to this brilliant discovery.

Physico-chemical research continues on its part to furnish means of investigation enabling us to penetrate more deeply into the very life of the chemical molecule, that is, those inner movements whose existence must now be admitted.

Spectroscopy, which has just yielded to M. Lecoq de Boisbaudran two new metals, reveals, by the comparison of the rays, a connection, which is assuredly far from accidental, between the various elements of the same family.

Thermo-chemistry, after having, in the hands of M. Berthelot and M. Thomsen, given the reason of most reactions, now approaches the study of isomeric bodies. M. Bouty's researches on the conductivity of the solutions of salts, and those of M. Raoult on the lowering of the freezing-point of the various solutions, seem to supply fresh means for determining the molecular weight of compounds.

But our attention must now be directed to mineralogy, a far less popular science than chemistry.

After being held in considerable esteem at the close of the last and beginning of the present century, when Werner's labours enabled mineralogists to describe and methodically classify the rich materials accumulated in collections, mineralogy lost its votaries according as it became more scientific. The immortal labours of Haüy, of Berzelius, and the chemical school, seem to have scared the amateurs, who probably saw in mineralogical collections little more than so many picturesque specimens distinguished by their diversified colours and fantastic forms.

Mineralogy presents the special character that it profits by the progress of chemistry and physics, for which it has itself often enough supplied the starting-point. Aiming especially at the description of crystallised minerals, it applies to this description methods which are afterwards profitably transferred to the domain of artificial products.

Thus it has given birth to crystallography, which establishes the laws determining the formation of crystals—those marvellous products of the mineral world in which Haüy recognises the regular aggregations of infinitely minute particles.

This regularity of structure, indicated at once by their outward form, has been confirmed by the study of their many physical properties, especially that of their action on light. From this study has been derived one of the safest and most fruitful processes by which the inward architecture of crystals has

been revealed. This consists in examining their action on polarised light, that is, on light which, by reflection or refraction under suitable conditions, has acquired special properties, and become incapable of being reflected or refracted like ordinary light, except under certain well-defined conditions.

To use a somewhat crude comparison, the luminous ray, after traversing certain media, assumes the appearance of an iron rod that has been passed through a rectangular drawing-frame. If on leaving the frame it meets an opening of like form and size, it will pass through without difficulty; but if the opening be placed crosswise, it can no longer pass.

There is this difference between the rod and the ray—that in all the intermediate positions a portion of the latter will pass through, the quantity increasing according as a more parallel disposition is assumed. Hence, if we take two apparatus corresponding to the frame and the opening, one of which supplies the polarised ray and the other intercepts it at right angles, the result will be complete darkness on the field of the instrument. But if we now place between both a crystalline plate of some substance which does not crystallise in the cubic form, we shall generally see the dark field illumined and often assuming the most lovely colours—an effect due to an action discovered by Arago and explained by Fresnel. With a homogeneous crystal, and when the light falls in parallel pencils on the plate, a uniform tint is diffused over the whole field of the instrument. If the crystal be not homogeneous, but formed of diverse parts jointed or regularly grouped together, but in positions not parallel, we shall get different tints for the different parts. By turning the crystal round, certain coloured strands will be extinguished, as we say, that is, will cease to transmit the light, while others will remain luminous. Hence we have here an extremely delicate and accurate means of studying the structure of crystals in their most intimate details. Haüy had already remarked that all crystals are doubly refracting, except those belonging to the cubic system. Brewster soon after thoroughly established the relation that exists between the optical properties and crystalline symmetry, stating, amongst other points, that cubic crystals alone have no action on polarised light. Nevertheless, observation had shown that certain substances affecting the cubic form had such action, and illumined the obscured field of the polarising apparatus. Biot had even suggested a term to designate, if not to explain, this exception, calling it “lamellar polarisation.”

To the researches of M. Mallard we are indebted for the true account of this anomaly, which in fact he has explained away. He shows that the cubic crystals acting on the polarised light are not really cubic, but formed by the regular grouping of parts belonging to other crystalline systems. Boracite, for instance—chloroborate of magnesium usually taking the form of rhombic dodecahedra, that is, a solid of twelve equal rhombs belonging to the cubic system—is formed by the union of twelve straight pyramids with rhombic bases, whose summits unite in the centre of the crystal, and whose bases are the rhombic facets.

M. Mallard's beautiful experiments with parallel rays have been confirmed by those of M. Emile Bertrand with convergent rays, showing in isolated portions of the garnet and of boracite all the properties belonging to regular crystals of orthorhombic substances.

There can be no doubt as to the correctness of the explanation given by M. Mallard of the optical anomalies of crystals which had been regarded as cubic, but which have once more served to illustrate the trite remark, “Trust not appearances.”

The optical investigation of crystals, due mainly to the late M. de Seuarumont, has become a familiar process which no mineralogist can henceforth afford to neglect.

These same methods, employed with much greater magnification than in Amici and Nörremberg's primitive appliances, also render the greatest services to the geologist in the study of rocks. They enable him to determine with an otherwise unattainable accuracy the minutest elements of these formations, in which minerals are intermingled in diverse proportions. After Sorby, the pioneer in this line of investigation, Zirkel and Rosenbusch in Germany, Fouqué and Michel Lévy in France, have turned to the best account the new method, which has thrown much light on the origin and mode of formation of certain rocks, by showing what substances were first solidified and what parts resisted longest the cooling process.

All these determinations are aided by the study of the optical sign of crystals—that is, the relative velocity with which the two polarised rays are propagated in certain directions—the observation of the position of the axes wherever possible, that of

dichroism, and even the approximate measurement of the indices of refraction.

This last has been much facilitated by an instrument recently devised by M. Emile Bertrand. With a transparent or opaque plate of some crystallised substance, and by means of not more than four readings made in two positions of the crystal, we obtain, by the determination of the angle of total reflection, the two or three indices, and consequently the wave-surface of the crystal for all bodies not having too high an index of refraction. And these operations, hitherto impracticable except with prisms or plates of great size, may now be made on extremely small crystals, such as those of rocks.

But however paramount the importance of optical properties, others also claim attention in crystallo-physics. Although of less practical interest in the determination of crystals, they may still open up many new avenues of inquiry to the physicist.

The curious property possessed by some hemihedral minerals of becoming charged with electricity with contrary signs at the two extremities of certain axes when heated or chilled has long been known. MM. J. and P. Curie have now shown that compression on the same crystals acts like the cooling, depression or traction like the heating process. In both cases the phenomenon appears due to the greater proximity or distance of the molecules. It is remarkable that the phenomenon may be reversed, so that hemihedral crystals with inclined facets properly charged with electricity, positive at one and negative at the other extremity, will contract or expand as the case may be.

As regards synthetic mineralogy, it is now known, thanks mainly to the researches of Berthier, Becquerel, Senarmont, H. Sainte-Claire Deville, and Daubrée, that minerals may be reproduced in our laboratories, and that we already possess a valuable means of study, enabling us to understand the conditions in which the natural minerals and their compounds may have been produced. We are thus advancing towards a chemical knowledge of certain species, whose formula analysis alone has failed to establish, and it may even soon be possible to produce useful substances under the very form from which they derive their properties.

The observation of the crystalline products accidentally formed in the metallurgic furnaces first led to this line of study, the firstfruits of which Mitscherlich and Berthier obtained by fusion.

By melting certain silicates, certain rocks or substances with the same chemical composition, and then exposing this vitreous mass to a temperature somewhat lower than that of fusion, MM. Fouqué and Michel Lévy have succeeded in reproducing the identical minerals found in lavas, basalts, and other eruptive rocks. Such are the anorthite and labrodorite feldspars, amphibene, pyroxene, peridot, magnetic iron, &c.

The case is otherwise with the granites, the problem of whose origin is far more difficult to solve. Nevertheless, of their three constituents two have already been artificially obtained.

Quartz had long ago been reproduced by Senarmont by heating gelatinous silica with a solution of hydrochloric acid to about 300° C. But Hautefeuille was the first to obtain fine crystals of orthoclase and albite feldspars by heating silica with alumina and the necessary alkalis in presence of a solvent such as a fused alkaline vanadate or tungstate.

But the conditions of this beautiful experiment do not appear to have been realised in nature. The nearest approach to them was probably the series of essays made by our President jointly with M. Edmond Sarrasin, by heating a solution of alkaline silicate with a precipitated silicate of alumina to nearly 500° C. in a strong steel tube lined on the inside with platinum. According to the alkalis and proportions employed, the result is albite or orthoclase mixed or not with quartz, the crystals resembling those occurring in nature and presenting the same peculiarities of form and grouping. The well-ascertained presence of drops of water in the granitic quartz seems to show that these granites must have been formed in the presence of aqueous solutions. Thus the natural conditions have already been approached, but will not be entirely realised until the hitherto recalcitrant mica has been obtained.

The first essays at reproducing the zeolite group of minerals have been made by De Schulten, who, by heating the silicate of soda in tubes of aluminous glass, has procured small icositetrahedra of analcime, such as occur in the lavas of the Cyclops Islands.

As regards precious stones, the solution of the problem from the scientific, if not the economic, standpoint, was long ago



given for spinel and corundum by Gaudin, Ebelmen, H. Sainte-Claire Deville, and Caron. More recently, MM. Frémy and Feil have prepared the ruby in large crystalline masses unsuitable for cutting, although possessing all the properties of the natural mineral.

Fresh essays seem to have led to more practical results, as for some time past rubies of fair dimensions are met with in the trade, which, although rather less brilliant and transparent, possess the hardness, density, and optical properties of this valuable gem. Several features of their inner structure show conclusively that they were obtained by fusion; in any case it is well known that, unlike silica, which remains vitreous, alumina crystallises by fusion.

The diamond alone appears to have hitherto resisted all attempts at reproduction. Although success in this direction has been frequently announced, the statement has always proved erroneous. The problem is rendered more difficult from the fact that the diamond has nowhere been found in its original lode. This holds good as well for the Brazilian itacolumites and quartzites, and for the serpentine breccias of South Africa, as for the diamantiferous sands. Nevertheless, in the diamond are occasionally embedded some foreign substances, which, while depreciating its commercial value, are very interesting as showing that it must have been formed at a relatively low temperature.

But enough has been said, M. Friedel concluded, to enlist your interest in mineralogy, a science whose progress has been rapid, whose methods are being constantly renewed, and which in every respect deserves the attention of inquiring minds.

### SCIENTIFIC SERIALS

*American Journal of Science*, August.—On hitherto unrecognised wave-lengths, by S. P. Langley. The object of the laborious and delicate operations here fully described has been, not so much to settle the theoretical questions involved in determining the relation between dispersion and wave-length, as to enable future observers to determine the visible or invisible wave-lengths of any heat, whether from a celestial or terrestrial source, observed in any prism. A knowledge will thus be gained of the intimate constitution of radiant bodies, which an acquaintance with the vibratory period of their molecules can usually alone afford. These researches into the whole unexplored region of infra-red energy both from celestial and terrestrial sources have led to the certain determination of wave-lengths greater than 0.005 mm. Radiations have also been recognised whose wave-length exceeds 0.03 mm., so that, while the wave-length known to Newton has been directly measured to nearly eight times, there is probable indication of wave-lengths far greater. The gulf between the shortest vibration of sound and the longest known vibration of the ether has thus in some measure been already bridged over.—On the chemical composition of herderite and beryl, with note on the precipitation of aluminium and separation of beryllium and aluminium, by S. L. Penfield and D. N. Harper. The composition of herderite is shown to be an isomorphous mixture of  $\text{CaBeFPO}_4$  with  $\text{CaBe(OH)PO}_4$ , which may be written  $\text{CaBe(FOH)PO}_4$ , or a salt of phosphoric acid, two of whose hydrogen atoms have been replaced by a bivalent element, and the third also by a bivalent element whose other free affinity has been satisfied by a fluorine atom or bydroxyl. Chemically it is closely related to wagnerite, triplite, and triploidite, these minerals offering the best illustration of the isomorphism of F and OH. In crystallisation, herderite is orthorhombic, with a prismatic angle of nearly  $120^\circ$ . Regarding water as an essential constituent of beryl, the authors add  $\frac{1}{2}\text{H}_2\text{O}$  to its usually accepted formula, writing it  $\text{H}_3\text{Be}_6\text{Al}_4\text{Si}_2\text{O}_{37}$ . Its theoretical composition, according to this formula, becomes  $\text{SiO}_2$  65.81;  $\text{Al}_2\text{O}_3$  18.83;  $\text{BeO}$  13.71;  $\text{H}_2\text{O}$  1.65. Specific gravity, 2.705.—Communications from the U.S. Geological Survey, Division of the Rocky Mountains, by Whitman Cross and L. G. Eakins. The present paper deals with pitilolite, a new mineral occurring in cavities of a more or less vesicular augite-andesite, which is found in fragments in the Tertiary conglomerate beds of Green and Table Mountains, Jefferson County, Colorado. It is described as a white substance in extremely delicate tufts and spongy masses composed of short hair-like needles loosely grouped together; hence its proposed name of pitilolite, from the Greek  $\pi\tau\iota\lambda\omicron\nu$  = down, in reference to the light downy nature of its aggregates. Its empirical formula is  $\text{RO}, \text{Al}_2\text{O}_3, 10\text{SiO}_2 + 5\text{H}_2\text{O}$ , R representing Ca,  $\text{K}_2$ , and  $\text{Na}_2$ ; it

is thus an aluminosilicate of which no previously described hydrate contains so high a percentage of silica. In this respect it may compare with the rare mineral milarite.—Notes on the peridotite of Elliot County, Kentucky, by J. S. Diller. This formation, described as a dark greenish rock with specific gravity 2.781, appears to be undoubtedly of eruptive origin, traversing many thousand feet of palaeozoic strata to reach the surface. Its mineralogical composition shows 40 per cent. of olivine, 30.7 serpentine, 14 dolomite, 8 pyrope, 2.2 ilmenite, 2 magnetite, with smaller quantities of biotite, enstatite, octahedrite, and apatite.—Temperature observations at the Lake Superior Copper-Mines, by H. A. Wheeler. The unusually low thermal gradients recorded in these mines—about  $1^\circ\text{F}$ . to 100 feet as compared with the normal of  $1^\circ\text{F}$ . to 50 or 55 feet in vertical descent, is attributed to the proximity of the cold waters of Lake Superior. The nearer the mines are to this great cooling influence, the lower the thermal gradient will be found to be.—An application of the copper reduction test to the quantitative determination of arsenic, by Henry Carmichael. Using a standard square of copper as an indicator, the author has been led to adopt the method here described, which, for the estimation of small quantities of arsenic in the human system or elsewhere, he believes to be quicker, simpler, more delicate, and, in the hands of toxicologists, less exposed to fallacy, than any other. A copper square 1 millimetre on a side detects 0.000025 grm. arsenious oxide, a quantity 400 times less than that necessary for turning the beam of the ordinary chemical balance.—On the crystallisation of gold, by Edward S. Dana. The paper deals more especially with the delicate crystalline threads and arborescent forms from the White Bull Mine, Oregon, and the specimens of finely crystallised gold from the Californian mines. The crystals are illustrated and fully described.—Classification of the Cambrian system of North America, by Charles D. Walcott. The formations here treated are those characterised by the predominance of the types of Barrande's "First Fauna," and such additional strata, not characterised by the presence of fossils, as are stratigraphically and structurally connected with the Cambrian strata identified by organic remains. These formations, showing a total thickness of over 18,000 feet, with a known fauna of 92 genera and 393 species, are regarded, not as a subdivision of the Silurian, but rather as a well-defined geological system underlying the Lower Silurian (Ordovician) on the North American continent.—Note on the spectrum of Comet  $\epsilon$ , 1886, by O. T. Sherman. When observed with the equatorial of Yale Observatory in May and June, this comet presented no less than seven loci of light where three only are usually seen. These showed approximate wave-lengths 618.4, 600.6, 567.6, 553.7, 517.1, 468.3, and 433.2, besides strongly suspected loci at 545.4, 535.0, 412.9, and 378.6. These are compared with the low temperature spectrum of carbohydrogen, and it is suggested that a chart should be prepared for the carbon compounds at successive heat-levels, after the manner of that drawn up by Lockyer for the photographed spectra of some carbon compounds (*Proc. Roy. Soc.*, xxx, p. 463).

*Annalen der Physik und Chemie*, Bd. xxviii., No. 7, July 1886.—Th. Schröder, experimental investigation of the influence of temperature upon elastic reaction. The experiments were made with three wires, respectively of silver, iron, and german silver. The elastic reaction was greatest with the first, least with the last of these, and the change in the elastic reaction produced by change of temperature followed the same order.—E. Warburg, remarks on the pressure of saturated vapour. Discusses relation between vapour-pressure and curvature of liquid surface.—W. Fischer, on the pressure of saturated vapours above liquid and above solid substances. The substances chosen were ice and water. The difference, for ice, between the two differential coefficients of pressure with respect to temperature for saturated steam over ice and saturated steam over water is 0.0465, at the melting-point, where the two curves meet. For benzol the two curves do not meet at its melting-point.—A. Schrauf, on dispersion and axial density in prismatic crystals; and on the properties of trimetric crystals. The latter shows the existence of a relation between coefficients of expansion, axial density, and the parameters of the crystal.—A. Toepler, some lecture experiments on waves. A small gas flame is used to show the propagation of a wave of compression in a long tube filled with air, and provided at one end with an india-rubber pear. Several interesting experiments can be shown.—E. Cohn